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THE NATURE OF GROUND CLUTTER AFFECTING RADAR PERFORMANCE

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ABSTRACT

The purpose of this paper is to study and evaluate some types of clutter which causes the degradation of radar performance. This study will take into account the clutter introduced from land, and other manmade objects such as large buildings and so on. Otherwise clutter targets reduce radar performance because of difficulty of separating them from moving targets and the detection of target in such a situation affects the operating capability of radars. Clutter targets are either isolated or composed. An isolated target is on which can be considered as a ''point'' scattered. It's sufficiently small in size to be included with in the area covered by the antenna beam. With the composed clutter target is more usual and it's characterized of most ground clutter. It consist of many individual scatters within the coverage of the radar antenna beam

KEYWORDS: Types of Clutter, Radar Performance, Detection of Target & Operating Capability

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INTRODUCTION

Clutter is the term applied to the radar returns resulting from the interception of the radar beam with land, or other manmade objects such as large buildings , Towers and so on. The presence of clutter almost always causes degradation of radar performance as clutter returns compete with target

Returns in the radar detection circuitry. Since objects causing clutter returns occupy large areas they represent large target cross section, thereby reducing small target detection capability. In low PRf pulsed radars where range to the target is determined by time delay between transmitted and received energy, clutter target reduce radar performance because of difficulty in separating them from moving targets. In radars operating on Doppler principle the situation is somewhat better as the stationary clutter targets have no velocity component along the line of sight while the returns from moving target being of greater interest, are shifted in frequency proportional to their velocity along the line of sight.(1)

Ground based radars are affected by clutter in low grazing angles and also from returns of buildings and mountains which are at higher altitude than the transmitting radar antenna In low PRf ground based radars, where range is obtained by time discrimination, clutter returns energy affects radar ; performance but slightly Clutter targets are either isolated or composite.

An isolated target is one which can be considered as a "point" scattered. It is sufficiently small in size to be included within the area covered by the antenna beam width. An example of an isolated clutter target is a water tower.

The composite clutter target is more usual and is characteristic of most ground clutter, sea clutter, chaff, and meteorological echoes. It consists of many individual scatters within the coverage of the radar antenna beam

Since in these radar clutter returns result from low angles of incident where the magnitude of back- scattering coefficient Figure 1 is relatively low and in addition the radar beam only, partially strikes the ground.

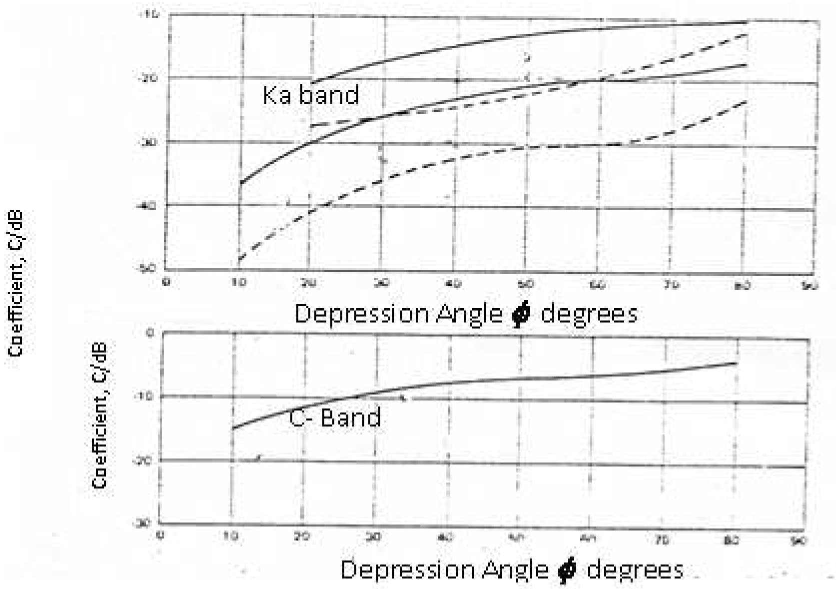

Figure 1: Radar Cross Section Coefficient C against Depression Angle Over Land, Typical of Attenuation Values

THE EFFECT OF EARTH ON THE RADAR

High frequency (HF) wave (3 –30 Mhz) literally reach around the earth because they propagate beyond the line -of-sight. This propagation is caused by diffraction along the curvature of the earth and by sky waves being refracted in the ionosphere. Although over the horizon radars have been developed, most radars use microwaves. For microwaves the range limit is defined by the radar horizon. (2)

Electromagnetic waves bend slightly because of atmospheric refraction. The refraction is caused by the fact that the index of refraction of the atmosphere is a function of height above the earth.

For a smooth earth, there is a demarcation in visibility because of earth's curvature. The apparent demarcation (horizon) depends on the index of refraction. The index of refraction is essentially independent of radar (or radio) frequency. However, the refractive index for radar (or radio waves) is different from that for visible waves. Refraction causes the horizon to be at a greater distance than if the waves traveled in straight lines. The geometric horizon is the horizon that would exist if were along perfectly straight 1ines.

For visible waves, the index of refraction depends only on temperature and pressure, but for radar the refractive index •depends (in complicated way) on temperature, pressure, and, the water vapor content of the atmosphere. Therefore , under normal conditions when radar range is 'limited only by the horizon, microwave radar "sees" at greater distances than can be seen visually. Microwaves actually to propagate beyond the horizon because of diffraction from the earth (which serves as the radiating surface), but the signal strength due to diffraction alone is very weak.

NATURE OF GROUND CLUTTER

Echo from land is caused by plants, trees, rock, hills and even bare ground. For some purposes, land scatters can

be grouped into two general classes: (1) those that are moved by. wind, and (2) the relatively fixed objects such as tree trunk , rocks and bare hills. if there are moving scatters grass , leaves and possibly branches , there are usually many within an illuminated area. therefore. it seems that the moving scatters should have electromagnetic properties similar to those of a large collection of random. (3)

The classification fixed and moving are broad Generalities and in fact , whither a scattered is of one class or wave length. for example , received reradiating from a tree branch that is moving back and forth through one centimeter goes through nearly all possible electrical phases for millimeter wavelengths , but the phase is nearly constant for decimeter wavelengths. Therefore other factors being fixed , the percentage of echo power from fixed and moving scatters illuminated by the radar depends on wavelength. In other words , the rapidly of echo fluctuation and the statistical distributions of the amplitudes are wavelength dependent.

Ground clutter affects the ground based radar. The higher the radar is above ground , the greater will be amount of clutter the radar will : see ".

In ground - based radar, clutter signals are primari1y from fixed, permanent targets. Buildings, towers and other man-made structures give more intense echo signals than ordinary countryside because of the presence of flat reflecting surfaces and "corner reflectors".

Bodies of water, roads, and air port runways backscatter little energy but are recognizable on radar PPI displays since they appear as black areas amid the brightness of the surrounding ground echoes. A hill will appear to stand out in high relief since the near side will give a large return, while the far side, which is relatively hidden from the view of the radar, will give a small return. (1)

If the antenna beam width is broad so that individual targets are not resolved, reflectors display of typical ground return might consist of many bright spots rather than a smooth homogeneous area. Because of the statistical, ever-changing nature of most clutter echoes with time, the conglomeration of spots on the ppl display representing clutter may differ from scan to scan. As it is not always possible to correlate the spots that appear on one scan with those that appeared on the previous scan.

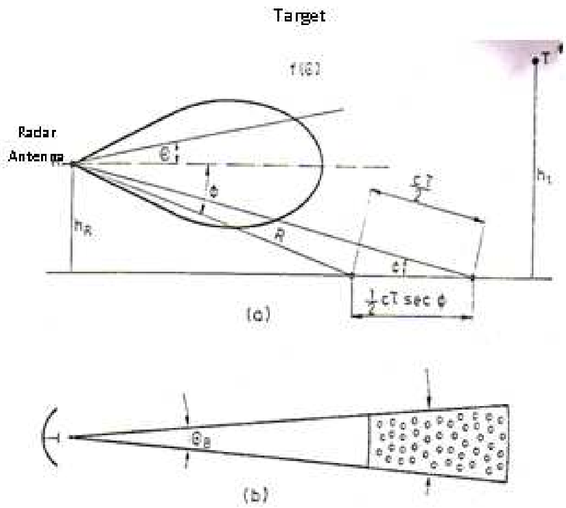

Figure 2: Geometry of Radar Clutter

NUMERICAL FORMULATION

The classical radar equation is

$$S = \frac{P G^2 \lambda^2 \delta}{(4\pi)^3 R^4} \tag{1}$$

From the diagram above we can obtain that the clutter area is

$$A = L.\ d \tag{2}$$

Where 1 equal $R\phi o$

R: the range of radar

ϕ_o: the elevation beam width angle

And d is the distance intercepted by radar beams and equal

$1/2\ c\tau \sec \phi$

And we have also

$$\delta = \delta o.\ A \tag{3}$$

Where δ o: is the radar cross section per unit area intercepted by antenna beam.

So

$$A = R\ \phi o \frac{C\ \tau}{2 \cos \phi} \tag{4}$$

Therefore

$$C = \frac{PG^2 \lambda\ \delta o\ \phi o\ C\tau}{(4\pi)^3 R^4 .\ 2 \cos \phi} \tag{5}$$

C: is the clutter power obtained from radar equation we have

$$S = \frac{PG^2 \lambda\ \delta}{(4\pi)^3 R^4}$$

Therefore

$$\frac{S}{C} = \frac{\dfrac{PG^2\lambda^2\delta o}{(4\pi)^3R^4}}{\dfrac{PG^2\lambda^2\delta o\,\phi oC\tau}{(4\pi)^3R^3\,.2\cos\phi}}$$

$$\frac{S}{C} = q_c = \frac{2\cos\phi\,.\,\delta}{R\delta_o\phi_o\,c\tau}$$

$$R = \frac{2\cos\phi\,.\,\delta}{\delta o\,\phi_o\,c\tau\,q_c}$$

$$\cos\phi = \frac{\sqrt{R^2 - hr^2}}{R} = 1 - \sqrt{\frac{hr}{R}\left(^2\right)}$$

$$R = \frac{\sqrt{1-\left(\dfrac{hr}{R}\right)^2\delta}}{\delta o\,\phi_o\,c\tau\,q_c} \tag{6}$$

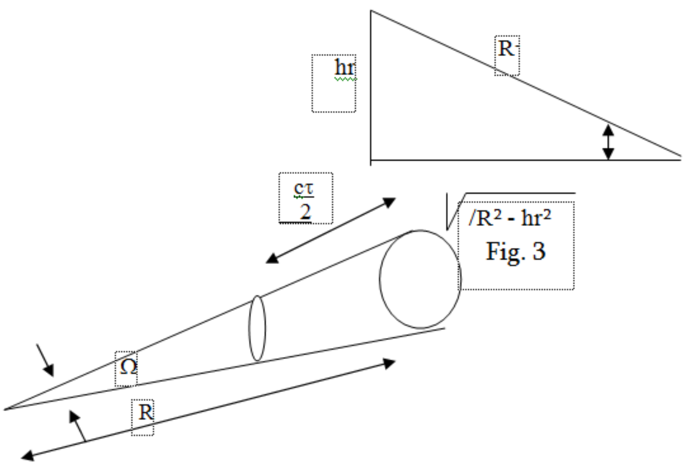

Figure 3: Plane View Showing Clutter Patch Consisting Of Individual, Independent Scatters.

The solid volume $R^2\,\Omega$.

Where Ω is the sold angle

The volume of clutter intercepted the radar beam is

$$V = \frac{R^2 . \Omega . C\tau}{2} \tag{7}$$

The cross section of the target at clutter will be n. V where n is the reflectivity of the volumetric scatter of on

$$C = \frac{}{(4\pi)^3 . R^4}$$

$$= \frac{PG^2\lambda^2 R^2 c\tau n}{(4\pi)^3 . R^4 . 2}$$

The gain of the antenna is

$$G = 4\pi / \Omega \tag{8}$$

Therefore $\Omega = 4\pi / G$

$$C = \frac{PG^2\lambda^2 n R^2 . 4\pi c\tau}{(4\pi)^3 . R^4 . G}$$

$$C = \frac{P G \lambda^2 \eta c\tau}{(4\pi)^2 R^2 . 2 . G}$$

By dividing (1. 1) on (1. 9) we obtain

$$\frac{S}{C} = \frac{\dfrac{P^2\eta^2\lambda^2\delta}{(4\pi)^3 R^4}}{\dfrac{p . \lambda^2 \eta c \tau G}{(4\pi)^2 R^2 . 2}} = q\,c$$

$$q_c = \frac{G \quad \delta}{2 \pi R^2 \eta C \tau}$$

$$R = \frac{\sqrt{G \quad \delta}}{2 \pi \ \eta C \tau q_c} \tag{9}$$

RESULTS

The transmitted radar energy is attenuated in traveling through the medium. Typical of attenuation values are given in Figure 1. As a function of wave lengths.

This attenuation reduces target detection capability as the energy incident on the target is reduced echo from land is caused by plants , trees , rock , hills and even bare ground. For some purposes , land scatters can by grouped into tow general classes (1) those that are moved by wind and (2) the relatively fixed objects such as tree , trunks , rocks and bare hills if there are moving scatters grass , leaves and possibly branches , there are usually many within an illuminated area. Therefore it seems that the moving scatters should electromagnetic properties similar to those of a large collection of random scatters

CONCLUSIONS

Ground – based radar will receive strong echo signals from terrain feature such as hills , mountains , or ever smooth surface if oriented properly.

Because reflections from hills and land surfaces are usually much greater than reflections from desired targets. such as aircraft. ground clutter can severely limit the detection capability of a non – MTI (moving target indication) radar. If the clutter is sufficiently large. The performance of even MIT radar will be degraded since a practical MIT radar. no matter how good , does not completely cancel all clutter.

The extent of ground clutter echoes may be further enhanced by non standard or super refraction effects. If the clutter is sufficiently large , extraneous echoes can appear in the receiver via the antenna Side lobes and add to the confusion.

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